

# **Envisage Environmental Incorporated**

P.O. Box 152, Richfield, Ohio 44286  
Phone (216) 526-0990

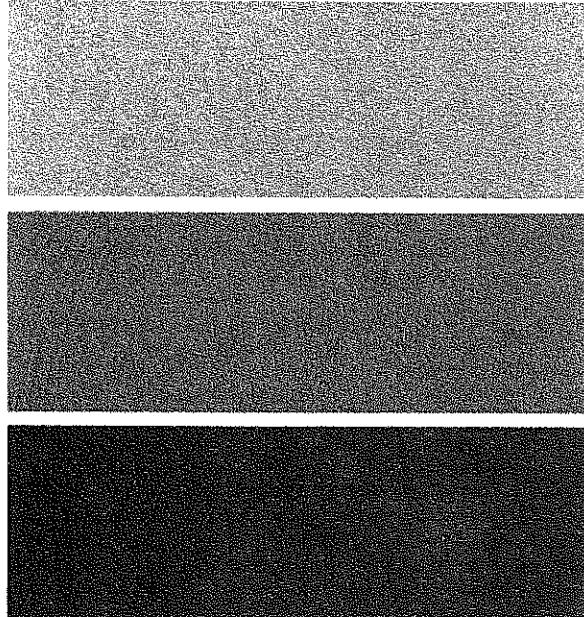
REPORT NO.	94-1120	3202
COMPANY	Hoover	
TITLE	Compliance	
DATE	2-18-94	

## **Question 5 - #4**

THE HOOVER COMPANY  
CANTON, OHIO

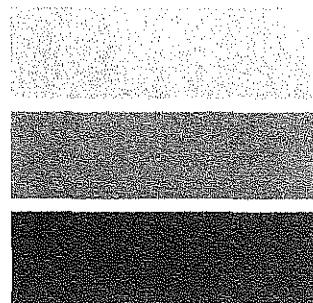
BOILER EXHAUST STACK - LOW LOAD  
PARTICULATE & SULFUR DIOXIDE EMISSION EVALUATION

CONDUCTED - FEBRUARY 18, 1994



# **SOURCE EVALUATION RESULTS**

**PREPARED BY**



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

# Envisage Environmental Incorporated

March 7, 1994

Mr. Gareth Rich  
The Hoover Company  
101 East Maple Street  
North Canton, Ohio 44720

Dear Mr. Rich:

The following report is the result of the particulate and sulfur dioxide emission evaluation conducted on February 18, 1994 at The Hoover Company, North Canton, Ohio. Testing was performed at the exhaust of the Wicks Coal Fired Boiler.

The results are true and accurate to the degree specified in the pertinent sections of the Code of Federal Regulations, in force at the time of testing concerning source sampling for sulfur dioxide and particulate matter.

We looking forward to answering any questions you may have and to assisting you in the future.

Respectfully submitted,

  
Greg Sankovich  
Environmental Project Leader

  
Frank Hezoucky  
Manager, Source Sampling  
ENVISAGE ENVIRONMENTAL INC.

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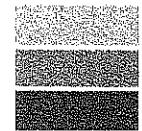
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## INTRODUCTION



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## INTRODUCTION

On February 18, 1994 Envisage Environmental Inc. conducted a particulate and sulfur dioxide emission evaluation at The Hoover Company, North Canton, Ohio. The testing was performed at the exhaust stack of the Wicks Coal Fired Boiler. The operation of the boiler was monitored throughout the duration of the testing by The Hoover Company personnel.

The purpose of the evaluation was to determine the particulate and sulfur dioxide emission rates from the unit to ascertain compliance with State and Federal Regulations. The Envisage testing team consisted of Messrs. Terry Campbell, and Jeff Belino. Mr. Gareth Rich, The Hoover Company, coordinated the testing. The Ohio Environmental Protection Agency, Canton Regional Health, was also present during the testing, and was represented by Mr. Andrew Pasko.

Results are presented in this report for pounds per million BTU, pounds per hour, and grains per dry standard cubic foot of emitted sulfur and particulate matter, as well as the various velocity, volumetric and temperature measurements associated with these tests.



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## DESCRIPTION OF PROGRAM



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## DESCRIPTION OF PROGRAM

The testing was conducted at the exhaust stack of the Wicks Coal Fired Boiler. The emission test consisted of three (3) test runs of USEPA Methods 1 - 5B and 6, Determination of Nonsulfuric Acid Particulate Matter from Stationary Sources and Determination of Sulfur Dioxide Emissions from Stationary Sources. Each of the three tests were performed over a seventy-two (72) minute period.

Six (6) sample/traverse points were utilized in each of the four (4) ports for a total of twenty four (24) sample/traverse points. The samples were withdrawn for three (3.0) minutes at each sample/traverse point. Samples were taken from the gas stream isokinetically through a five sixteenths (.3125) inch nozzle and a six (6) foot Pyrex lined probe. The entire length of the probe was heated and attached to a EPA Method 5 sample train modified for the collection of sulfur dioxide by removing the water and adding 80% IPA in the first impinger and 3% H<sub>2</sub>O<sub>2</sub> in the 2nd and 3rd. The hot box temperature was maintained between 295 and 345 degrees Fahrenheit. Exit gas temperature of the impingers was maintained below 68 degrees Fahrenheit with an ice bath. The nozzle, probe and connecting glassware were cleaned before testing and at the conclusion of each test run with acetone. Leak checks of the pitot tube lines and the sample train were all acceptable by EPA regulations.

Flue gas analysis for carbon dioxide, oxygen and carbon monoxide, was conducted by drawing an integrated air bag sample and analyzing it on a Hays Republic Model 621A "Orsat" Portable Gas Analyzer. The average of these readings for each run were used in calculating the emission rates.

Calibration of the equipment used, including the dry gas meter, temperature measuring devices, orifice meter, and the "S" type pitot tube was conducted within 60 days of the test date. Copies of the data are included in this report.



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## Description of Program - Cont'd

All analytical procedures were performed in accordance with the methods specified in the Code of Federal Regulations, Title 40, Part 60, Volume 43. Blanks were collected and analyzed on the distilled water, and acetone used in the evaluation. The residue from the distilled water was less than could be measured on a 0.1 milligram analytical balance and was considered zero. The acetone blank was recorded and incorporated into the results.

The example equations included in this report uses the figures from Run # 1.



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## TEST RESULTS SUMMARY

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## TEST RESULTS SUMMARY

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The Hoover Company  
Boiler Exhaust Stack - Low Load  
Particulate and Sulfur Dioxide Emission Evaluation  
Conducted - February 18, 1994

PARAMETER	RUN # 1	RUN # 2	RUN # 3
<b>Particulate Emissions</b>			
Pounds/Million BTU (Actual Heat Input)	0.1857	0.1332	0.1319
Pounds/hour	7.25	5.51	5.51
Grains/dscf	0.0507	0.0396	0.0392
<b>Sulfur Dioxide Emissions</b>			
Pounds/Million BTU (Actual Heat Input)	5.94	6.26	6.33
Pounds/hour	231.80	259.02	264.44
Pounds/DSCF	2.31E-04	2.66E-04	2.69E-04
<b>System Flow Rates</b>			
ACFM	35,658	34,622	34,626
DSCFM	16,701	16,227	16,409
Degrees Fahrenheit	548	545	547
Moisture Content	6.56	6.75	5.51



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## TEST RESULTS DETAILED



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## TEST RESULTS

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The Hoover Company

## Boiler Exhaust Stack - Low Load

## Particulate and Sulfur Dioxide Emission Evaluation

DATE: February 18, 1994	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
Time of Day			0900 1018	1100 1218	1245 1402
1 Gas Volume-dry, std.	Vmstd	cu. ft.	46.48	44.74	44.38
2 Condensate Vapor Vol.	Vwstd	cu. ft.	3.26	3.24	2.59
3 Gas Stream Moisture	Bws	vol.dec	0.0656	0.0675	0.0551
4 Mol.Wt-flue gas (dry)	Msd	lb/lb mo.	29.93	29.75	29.82
5 Mol.Wt-flue gas (wet)	Ms	lb/lb mo.	29.15	28.96	29.17
6 Flue Gas Velocity	Vs	ft/sec	39.62	38.47	38.47
7 Flue Gas Volume-Actual	ACFM	cu. ft.	35,658	34,622	34,626
8 Flue Gas Volume-Std.	DSCFM	cu. ft.	16,701	16,227	16,409
9 Particulate Conc.	Cs				
	- Probe	gr/dscf	0.0124	0.0073	0.0078
	- Filter	gr/dscf	0.0382	0.0323	0.0314
	- Total	gr/dscf	0.0507	0.0396	0.0392
10 Emission Rate	E				
	- Probe	lb/hr	1.78	1.01	1.10
	- Filter	lb/hr	5.47	4.50	4.42
	- Total	lb/hr	7.25	5.51	5.51
11 Isokinetic Rate	I	%	108.9	107.8	105.8

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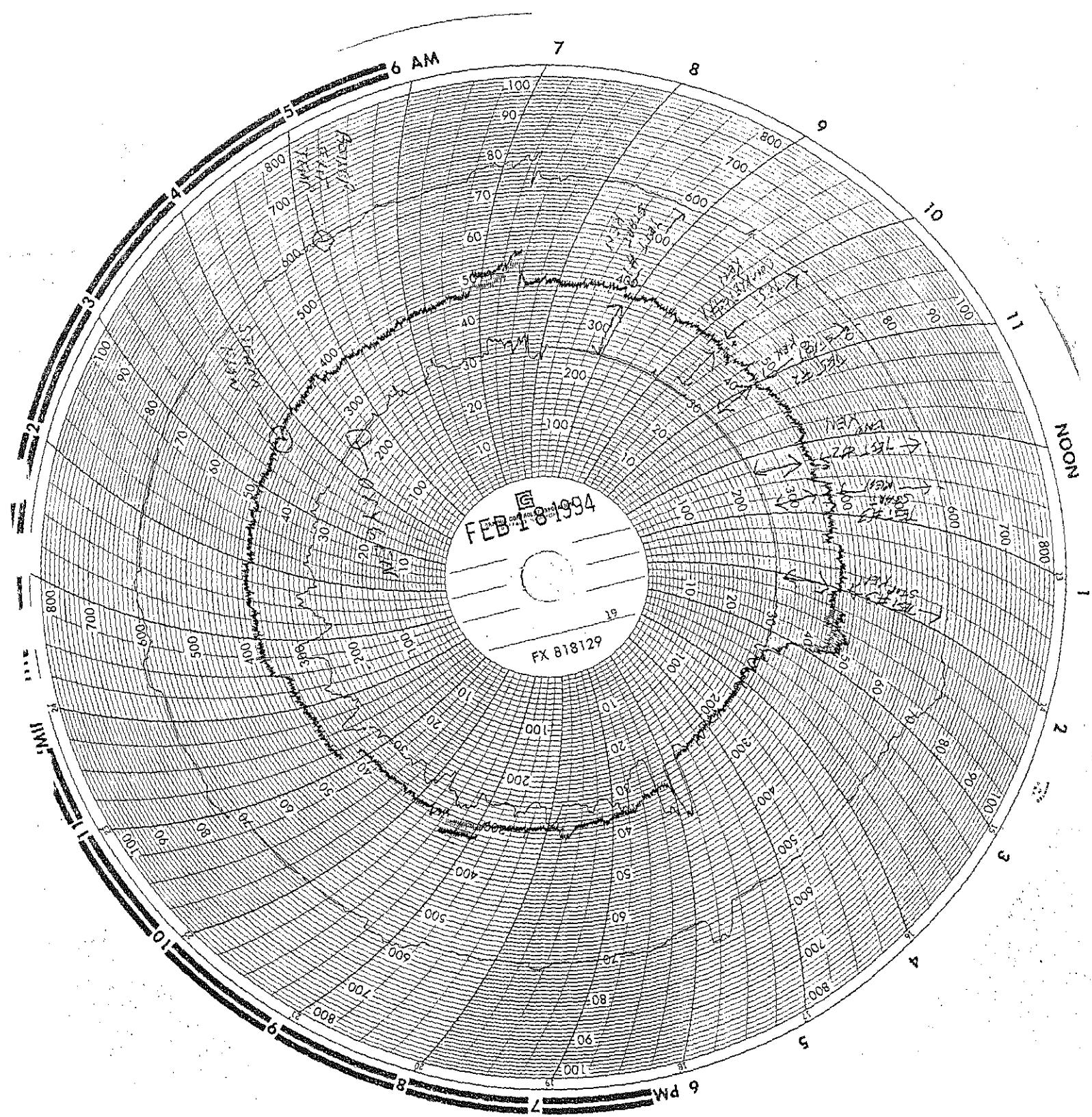
## OPERATIONAL PARAMETERS



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## CONTROL ASSOCIATES

## DATA COLLECTION &amp; JRS

Customer: Hoover Co.  
 Plant : N. Canton  
 Date : 2/18/94

Boiler: 3  
 Fuel : Coal

Test Type: EPA Compliance

Time	Gate Hght	Grate Speed	Wind Box "WC	Over Fire "WC	Furn Draft "WC	Blr Out "WC	Pri Dust Out	Sec Dust Out	Zone 1 "WC	Zone 2 "WC	Zone 3 "WC	Zone 4,5,6 "WC
9:00	9.25	3.5	1.95	22.0	0.19	0.25	2.5	4.5	1.0	1.4	N/A	N/A
9:15	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
9:30	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
9:40	Blow Soot											
9:45	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
10:00	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
10:18	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
End of first Run												
Time	Gate Hght	Grate Speed	Wind Box "WC	Over Fire "WC	Furn Draft "WC	Blr Out "WC	Pri Dust Out	Sec Dust Out	Zone 1 "WC	Zone 2 "WC	Zone 3 "WC	Zone 4,5,6 "WC
11:00	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
11:15	9.25	3.5	1.95	22.0	0.17	0.23	2.5	4.5	1.0	1.4	N/A	N/A
11:30	9.25	3.5	1.95	22.0	0.18	0.23	2.5	4.5	1.0	1.4	N/A	N/A
11:45	9.25	3.5	1.95	22.0	0.18	0.23	2.5	4.5	1.0	1.4	N/A	N/A
12:00	9.25	3.5	1.95	22.0	0.19	0.24	2.5	4.5	1.0	1.4	N/A	N/A
12:18	9.25	3.5	1.95	22.0	0.19	0.24	2.5	4.5	1.0	1.4	N/A	N/A
End of Second Run												
Time	Gate Hght	Grate Speed	Wind Box "WC	Over Fire "WC	Furn Draft "WC	Blr Out "WC	Pri Dust Out	Sec Dust Out	Zone 1 "WC	Zone 2 "WC	Zone 3 "WC	Zone 4,5,6 "WC
12:45	9.25	3.5	1.95	22.0	0.18	0.25	2.5	4.5	1.0	1.4	N/A	N/A
1:00	9.25	3.5	1.95	22.0	0.18	0.25	2.5	4.5	1.0	1.4	N/A	N/A
1:15	9.25	3.5	1.95	22.0	0.20	0.26	2.5	4.5	1.0	1.4	N/A	N/A
1:30	9.25	3.5	1.95	22.0	0.20	0.26	2.5	4.5	1.0	1.4	N/A	N/A
1:45	9.25	3.5	1.95	22.0	0.20	0.26	2.5	4.5	1.0	1.4	N/A	N/A
2:03	9.25	3.5	1.95	22.0	0.19	0.24	2.5	4.5	1.0	1.4	N/A	N/A
End of Third Run												

CONNELL ASSOCIATES

DATA COLLECTION BY: JRS

Customer: Hoover Co.  
 Plant : N. Canton  
 Date : 2/18/94

Boiler# 3 Test Type: EPA Compliance  
 Fuel : Coal

Steam Meter Design Pressure: --&gt; 150 PSIG

Time	Steam Flow	Crctd Steam Flow	Steam Hdr PSI	02 Recrd			BLR OUT °F	Coal Scale N	Coal Scale S
				02 Port	Opty %				
9:00	37000	35859	140	10.2	9.3	8.0	582	728593	727746
9:15	38000	36709	139	10.1	9.5	8.0	582	728595	727748
9:30	37000	35975	141	10.2	9.4	8.0	581	728597	727750
9:40	Blow Soot								
9:45	36500	35489	141	10.5	9.6	8.2	580	728599	727752
10:00	36200	35422	143	10.2	9.6	8.0	580	728601	727754
10:18 19	36300	36079	148	9.7	9.5	8.0	583	728603	727756

Post T Leak Rate  
For 2/17/94

Run #	Post Test Vac CFM	Post Test Vac "Hg	Post Test Run
			Run Vac "Hg
1	0.005	15.0	9.5
2	0.004	14.0	9.0
3	0.000	14.0	10.0

Post T Leak Rate  
For 2/18/94

Run #	Post Test Vac CFM	Post Test Vac "Hg	Post Test Run
			Run Vac "Hg
1	0.000	14.0	4.5
2	0.004	8.0	5.5
3	0.002	10.0	5.5

Time	Steam Flow	Crctd Steam Flow	Steam Hdr PSI	02 Recrd			BLR OUT °F	Coal Scale N	Coal Scale S
				02 Port	Opty %				
11:00	36500	36278	148	10.5	9.7	8.2	582	728609	727763
11:15	37200	37087	149	10.3	9.4	7.9	584	728611	727765
11:30	36800	36009	143	10.7	9.6	7.7	583	728614	727767
11:45	36700	35798	142	10.5	9.6	7.5	584	728616	727769
12:00	36200	35422	143	10.5	9.6	7.5	584	728618	727771
12:18 19	36000	36109	151	10.6	9.6	7.6	583	728620	727773

End of Second Run

Time	Steam Flow	Crctd Steam Flow	Steam Hdr PSI	02 Recrd			BLR OUT °F	Coal Scale N	Coal Scale S
				02 Port	Opty %				
12:45	36500	36500	150	10.3	9.5	7.5	584	728624	727776
1:00	36000	36000	150	10.3	9.6	7.5	583	728626	727780
1:15	36000	36000	150	10.5	9.2	7.8	583	728628	727782
1:30	37000	36988	149	10.5	9.1	7.7	580	728630	727784
1:45	37500	36811	144	10.3	8.9	8.0	580	728633	727786
2:03 19	36500	35716	143	10.3	7.9	7.9	580	728635	727788

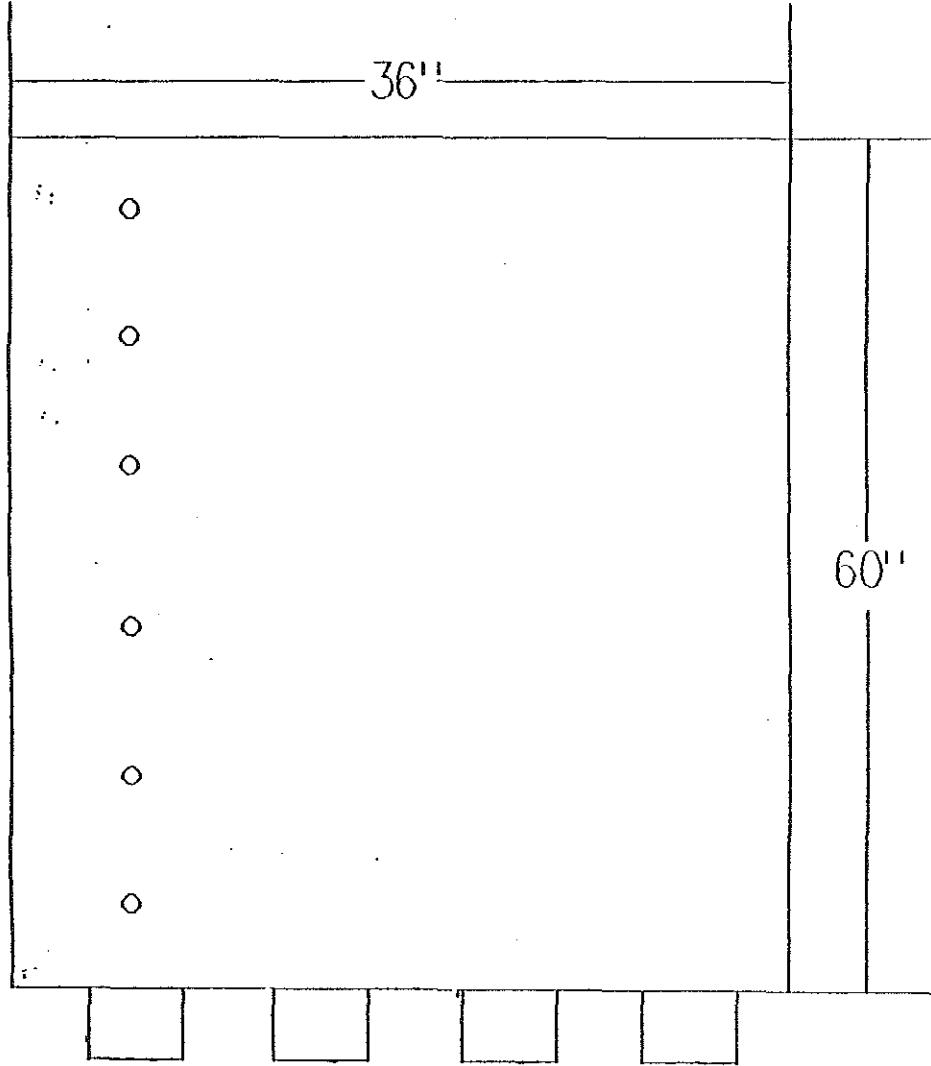
End of Third Run

## SAMPLE POINT LOCATION DIAGRAM



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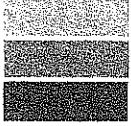
### Sample Point Distances

- 1) 55 inches
- 2) 45 inches
- 3) 35 inches
- 4) 25 inches
- 5) 15 inches
- 6) 5 inches

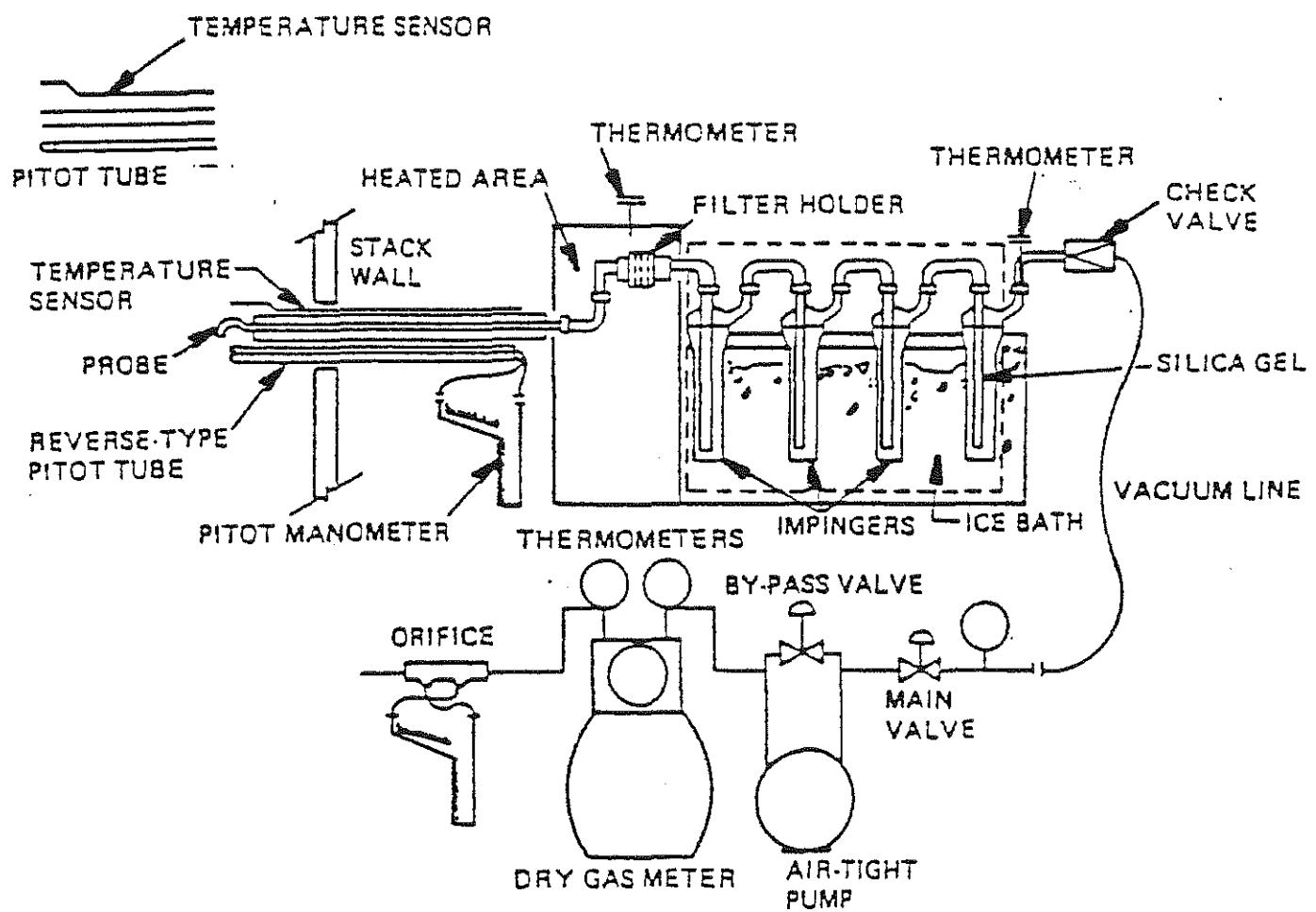
Upstream 0.8 Diameters  
Downstream 2.2 Diameters

The Hoover Company  
North Canton, Ohio  
Boiler Exhaust

## SAMPLING TRAIN DIAGRAM

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## METHOD 5/6 SAMPLE TRAIN



## LABORATORY SECTION



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## LABORATORY SUMMARY SHEET

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The Hoover Company

## Boiler Exhaust Stack - Low Load

## Particulate and Sulfur Dioxide Emission Evaluation

DATE: February 18, 1994	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
1 Sampling Time	t	minutes	72.0	72.0	72.0
2 Barometric Pressure	Pb	in. Hg	28.96	28.96	28.96
3 Static Pressure	Pg	in. H2O	-4.60	-4.60	-4.60
Stack Pressure	Ps	in. Hg	28.62	28.62	28.62
4 Gas Meter Volume	Vm	cu. ft.	52.68	51.16	51.08
5 Stack Area	A	sq. ft.	15.00	15.00	15.00
6 Nozzle Diameter	Dn	dec. in.	0.3125	0.3125	0.3125
7 Meter Temperature	Tm	degrees F	121.5	126.5	130.4
	Tm	degrees R	581.5	586.5	590.4
8 Stack Temperature	Ts	degrees F	547.7	545.0	547.1
	Ts	degrees R	1007.7	1005.0	1007.1
9 Velocity Head	<sup>^</sup> P	in. H2O	0.502	0.487	0.488
10 Orifice Pressure	<sup>^</sup> H	in. H2O	1.52	1.43	1.42
11 Carbon dioxide	CO2	%	9.4	8.2	8.6
12 Oxygen	O2	%	10.5	11.0	11.0
13 Carbon monoxide	CO	%	0.0	0.0	0.0
14 Nitrogen	N2	%	80.1	80.8	80.4
15 Pitot Coefficient	Cp		0.84	0.84	0.84
16 Water Collected	Vlc	ml	69.3	68.8	55.0
Sample Weight:	Mn				
17 - Probe		g	0.0374	0.0211	0.0224
18 - Filter		g	0.1152	0.0938	0.0903



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## SO2 LABORATORY SUMMARY

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The Hoover Company  
Boiler Exhaust Stack - Low Load  
Particulate and Sulfur Dioxide Emission Evaluation

DATE: February 18, 1994	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
20 Normality of Ba(ClO <sub>4</sub> ) <sub>2</sub>	N	meq/ml	0.0106	0.0106	0.0106
21 Volume of solution	Vsln	ml	255.0	260.0	245.0
22 Volume aliquot titrant	Va	ml	0.10	0.10	0.10
23 Volume Ba(ClO <sub>4</sub> ) <sub>2</sub> Blank	Vtb	ml	0.0	0.0	0.0
24 Volume Ba(ClO <sub>4</sub> ) <sub>2</sub> Sampl	Vt	ml	5.63	6.12	6.50

## SO2 TEST RESULTS

The Hoover Company  
Boiler Exhaust Stack - Low Load  
Particulate and Sulfur Dioxide Emission Evaluation

DATE: February 18, 1994	Units	RUN # 1	RUN # 2	RUN # 3	
12 Concentration SO <sub>2</sub>	C <sub>SO2</sub>	lb/scf	2.31E-04	2.66E-04	2.69E-04
13 Concentration SO <sub>2</sub>	PPM	ppmV	1391.4	1600.3	1615.6
14 Emission Rate SO <sub>2</sub>	E <sub>SO2</sub>	lb/hr	231.80	259.02	264.44



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PLANT The Hoover Company  
 DATE February 18, 1994  
 RUN NO. 1  
 CASE NO. 58

22

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
120	0.7074	0.5922	0.1152
N/A	N/A	N/A	N/A
302	106.1440	106.1066	0.0374

\* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED		
	IMPIINGER VOLUME (ml)	SILICA GEL WEIGHT (g)
FINAL	255	245.6
INITIAL	200	231.3
NET LIQUID COLLECTED	55	14.3
TOTAL NET VOLUME	69.3	* g      ml

\* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1 \text{ g/ml})} = \text{Volume Water, ml}$$



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PLANT The Hoover Company  
 DATE February 18, 1994  
 RUN NO. 2  
 CASE NO. 38

23

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
136	0.6848	0.5910	0.0938
N/A	N/A	N/A	N/A
671	94.8836	94.8625	0.0211

\* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED		
	IMPIINGER VOLUME (ml)	SILICA GEL WEIGHT (g)
FINAL	260	240.1
INITIAL	200	231.3
NET LIQUID COLLECTED	60	8.8
TOTAL NET VOLUME	68.8	* g      ml

\* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1 \text{ g/ml})} = \text{Volume Water, ml}$$



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PLANT The Hoover Company  
 DATE February 18, 1994  
 RUN NO. 3  
 CASE NO. 100

24

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
172	0.6877	0.5974	0.0903
N/A	N/A	N/A	N/A
200	101.8804	101.8580	0.0224

\* Corrected for Acetone Blank

VOLUME OF LIQUID WATER COLLECTED		
	IMPIINGER VOLUME (ml)	SILICA GEL WEIGHT (g)
FINAL	245	241.3
INITIAL	200	231.3
NET LIQUID COLLECTED	45	10.0
TOTAL NET VOLUME	55.0	* g ml

\* Convert weight of water to volume by dividing weight increase by density of water:

$$\frac{\text{Increase g}}{(1 \text{ g/ml})} = \text{Volume Water, ml}$$



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## ORSAT ANALYSIS WORK SHEET

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DATE: 2/18/94LOCATION: HooverOPERATOR: D.S., T.C.RUN # 1

	1		2		3		
	ACTUAL	NET	ACTUAL	NET	ACTUAL	NET	AVERAGE
CO <sub>2</sub>	9.4	9.4	9.4	9.4	9.5	9.5	9.43
O <sub>2</sub>	19.9	10.5	19.9	10.5	20.0	10.5	10.5
CO	19.9	0	19.9	0	20.0	0	0

RUN # 2

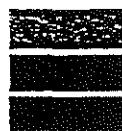
	1		2		3		
	ACTUAL	NET	ACTUAL	NET	ACTUAL	NET	AVERAGE
CO <sub>2</sub>	8.2	8.2	8.2	8.2	8.2	8.2	8.2
O <sub>2</sub>	19.2	11.0	19.2	11.0	19.2	11.0	11.0
CO	19.2	0	19.2	0	19.2	0	0

RUN # 3

	1		2		3		
	ACTUAL	NET	ACTUAL	NET	ACTUAL	NET	AVERAGE
CO <sub>2</sub>	8.7	8.7	8.6	8.6	8.6	8.6	8.633
O <sub>2</sub>	19.7	11.0	19.6	11.0	19.6	11.0	11.0
CO	19.7	0	19.6	0	19.6	0	0

COMMENTS: \_\_\_\_\_

FH-4-92



**Envisage  
Environmental  
Incorporated**

P.O. Box 152, Pleasanton, Calif. 94566  
Phone (415) 525-0990

AUDIT SAMPLE - Internal

Sulfur dioxide Concentration - Lot 0593 - Sample 7172

26

$$C_{SO_2} = K_2 \frac{(V_t - V_{tb}) N}{V_m(\text{given})} \left[ \frac{-V_{sln}}{V_a} \right]$$

(EPA Equation 6-2)

Nomenclature:

- $C_{SO_2}$  = Concentration of sulfur dioxide in Audit sample, mg/dscm.
- $K_2$  = Constant, 32.03 mg/meq.
- $V_t$  = Volume of barium perchlorate titrant used for the sample, ml (average of replicate titrations).
- $V_{tb}$  = Volume of barium perchlorate titrant used for the blank, ml.
- $N$  = Normality of barium perchlorate titrant, milliequivalents/ml.
- $V_{sln}$  = Volume of solution containing sulfur dioxide sample, ml.
- $V_a$  = Volume of aliquot titrated, ml.
- $V_m(\text{given})$  = Volume of gas sample (given with each audit sample), dscm.

Where:

$$C_{SO_2} = 32.03 \frac{(0.40 - 0.00)}{0.0210} \left[ \frac{100.0}{1.0} \right] = 646.7 \text{ mg/dscm}$$

$$\% = \left[ \frac{C_{SO_2} - C_{SO_2}(\text{given})}{C_{SO_2}(\text{given})} \right] \times 100$$

$$= \frac{646.7 - 650.0}{650.0} \times 100 = -0.5 \%$$



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

## Sulfur dioxide Concentration

$$C_{SO_2} = K_2 \frac{(V_t - V_{tb}) N}{V_m(\text{given})} \left[ \frac{-V_sln}{V_a} \right]$$

(EPA Equation 6-2)

## Nomenclature:

- $C_{SO_2}$  = Concentration of sulfur dioxide in Audit sample, mg/dscm.  
 $K_2$  = Constant, 32.03 mg/meq.  
 $V_t$  = Volume of barium perchlorate titrant used for the sample, ml (average of replicate titrations).  
 $V_{tb}$  = Volume of barium perchlorate titrant used for the blank, ml.  
 $N$  = Normality of barium perchlorate titrant, milliequivalents/ml.  
 $V_{sln}$  = Volume of solution containing sulfur dioxide sample, ml.  
 $V_a$  = Volume of aliquot titrated, ml.  
 $V_m(\text{given})$  = Volume of gas sample (given with each audit sample), dscm.

## Where:

$$C_{SO_2} = 32.03 \frac{(1.00 - 0.00)}{0.0210} \frac{0.0106}{0.0210} \left[ \frac{-100.0}{1.0} \right] = 1616.8 \text{ mg/dscm}$$

$$\Delta\% = \left[ \frac{-C_{SO_2} - C_{SO_2}(\text{given})}{C_{SO_2}(\text{given})} \right] \times 100$$

$$= \frac{1616.8 - 1600.0}{1600.0} \times 100 = 1.0 \%$$



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P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

Sulfur dioxide Concentration

$$C_{SO_2} = K_2 \frac{(V_t - V_{tb}) N}{V_m(\text{given})} \left[ \frac{V_{sln}}{V_a} \right]$$

Nomenclature: (EPA Equation 6-2)

- $C_{SO_2}$  = Concentration of sulfur dioxide in Audit sample, mg/dscm.  
 $K_2$  = Constant, 32.03 mg/meq.  
 $V_t$  = Volume of barium perchlorate titrant used for the sample, ml (average of replicate titrations).  
 $V_{tb}$  = Volume of barium perchlorate titrant used for the blank, ml.  
 $N$  = Normality of barium perchlorate titrant, milliequivalents/ml.  
 $V_{sln}$  = Volume of solution containing sulfur dioxide sample, ml.  
 $V_a$  = Volume of aliquot titrated, ml.  
 $V_m(\text{given})$  = Volume of gas sample (given with each audit sample), dscm.

Where:

$$C_{SO_2} = 32.03 \frac{(2.32 - 0.00)}{0.0210} \left[ \frac{100.0}{5.0} \right] = 749.1 \text{ mg/dscm}$$

$$\begin{aligned} \Delta\% &= \left[ \frac{C_{SO_2} - C_{SO_2}(\text{given})}{C_{SO_2}(\text{given})} \right] \times 100 \\ &= \frac{749.1 - 750.0}{750.0} \times 100 = -0.1 \% \end{aligned}$$



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Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0980

## COAL ANALYSIS

**Envisage  
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Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

## COAL ANALYSIS SUMMARY

30

The Hoover Company

Canton, Ohio

Boiler Exhaust

Particulate and Sulfur Dioxide Emission Evaluation

Conducted - February 18, 1994

## ULTIMATE DATA

		RUN 1	RUN 2	RUN 3
% H	As Rec'd Dry	4.86 5.18	5.10 5.44	4.98 5.29
% C	As Rec'd Dry	69.12 73.64	70.56 75.30	70.22 74.64
% S	As Rec'd Dry	3.19 3.40	3.24 3.46	3.05 3.24
% N	As Rec'd Dry	1.33 1.42	1.31 1.40	1.34 1.42
% O	As Rec'd Dry	8.10 8.62	7.70 8.21	8.23 8.76
% Ash	As Rec'd Dry	7.26 7.74	5.80 6.19	6.26 6.65

## PROXIMATE DATA

BTU/LB	As Rec'd	12,692	12,811	12,929
BTU/LB	Dry	13,522	13,671	13,743
MOISTURE %		6.14	6.29	5.92
Pounds of Coal Burned - Total		4,000	4,200	4,200
Pounds of Coal Burned - 60 minutes		3,077	3,231	3,231
Heat Input		39.05	41.39	41.77
F Factor		9591	9758	9566



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990



# COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (708) 953-9300

SINCE 1908

Member of the SGS Group (Société Générale de Surveillance)

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February 28, 1994

PLEASE ADDRESS ALL CORRESPONDENCE TO:  
2979 E. CENTER ST., CONNEAUT, OH 44030  
TELEPHONE: (216) 224-2261  
TELEX: 985-606 CT&E COUT  
FAX: (216) 224-2808

► ENVISAGE ENVIRONMENTAL  
6940 Miller Road  
Brecksville, OH 44141

Sample identification by  
ENVISAGE ENVIRONMENTAL

IDENT: 94-1117  
Run 1  
2/18/94

Kind of sample  
reported to us Coal

Sample taken at -----

Sample taken by Submitted

Date sampled -----

Date received February 24, 1994

Analysis Report No. 88-36361-A

## SHORT PROXIMATE - ULTIMATE ANALYSIS

	<u>As Received</u>	<u>Dry Basis</u>
% Moisture	6.14	XXXXX
% Carbon	69.12	73.64
% Hydrogen	4.86	5.18
% Nitrogen	1.33	1.42
% Sulfur	3.19	3.40
% Ash	7.26	7.74
% Oxygen (diff)	8.10	8.62
	100.00	100.00
Btu/lb	12692	13522 MAF 14656

Respectfully submitted,  
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Conneaut Laboratory



# COMMERCIAL TESTING & ENGINEERING CO.

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February 28, 1994

PLEASE ADDRESS ALL CORRESPONDENCE TO:  
2979 E. CENTER ST., CONNEAUT, OH 44030  
TELEPHONE: (216) 224-2261  
TELEX: 985-606 CT&E COUT  
FAX: (216) 224-2808

► ENVISAGE ENVIRONMENTAL  
6940 Miller Road  
Brecksville, OH 44141

Sample identification by  
ENVISAGE ENVIRONMENTAL

IDENT: 94-1117  
Run 2  
2/18/94

Kind of sample  
reported to us Coal

Sample taken at -----

Sample taken by Submitted

Date sampled -----

Date received February 24, 1994

Analysis Report No. 88-36361-B

## SHORT PROXIMATE - ULTIMATE ANALYSIS

### As Received      Dry Basis

% Moisture	6.29	XXXXX
% Carbon	70.56	75.30
% Hydrogen	5.10	5.44
% Nitrogen	1.31	1.40
% Sulfur	3.24	3.46
% Ash	5.80	6.19
% Oxygen (diff)	7.70	8.21
	100.00	100.00

Btu/lb      12811      13671      MAF   14573

Respectfully submitted,  
COMMERCIAL TESTING & ENGINEERING CO.

*K.D. Meier*

Manager, Conneaut Laboratory



# COMMERCIAL TESTING & ENGINEERING CO.

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February 28, 1994

PLEASE ADDRESS ALL CORRESPONDENCE TO:  
2979 E. CENTER ST., CONNEAUT, OH 44030  
TELEPHONE: (216) 224-2261  
TELEX: 985-606 CT&E COUT  
FAX: (216) 224-2808

► ENVISAGE ENVIRONMENTAL  
6940 Miller Road  
Brecksville, OH 44141

Sample identification by  
ENVISAGE ENVIRONMENTAL

IDENT: 94-1117  
Run 3  
2/18/94

Kind of sample  
reported to us Coal

Sample taken at -----

Sample taken by Submitted

Date sampled -----

Date received February 24, 1994

Analysis Report No. 88-36361-C

## SHORT PROXIMATE - ULTIMATE ANALYSIS

	<u>As Received</u>	<u>Dry Basis</u>
% Moisture	5.92	XXXXX
% Carbon	70.22	74.64
% Hydrogen	4.98	5.29
% Nitrogen	1.34	1.42
% Sulfur	3.05	3.24
% Ash	6.26	6.65
% Oxygen (diff)	8.23	8.76
	100.00	100.00
Btu/lb	12929	13743 MAF 14722

Respectfully submitted,  
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Conneaut Laboratory

OVER 40 BRANCH LABORATORIES STRATEGICALLY LOCATED IN PRINCIPAL COAL MINING AREAS, TIDEWATER AND GREAT LAKES PORTS, AND RIVER LOADING FACILITIES

## **EMISSION SAMPLING EQUIPMENT SPECIFICATIONS**



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

Equipment and Specifications  
U.S.E.P.A. Reference methods 1-5

## Control Unit (Meter Box)

## Equipment Designation

Envisage Environmental Inc.  
 Anderson Samplers  
 Remanufactured R.A.C.

Control Unit #'s MB- 08 & 09  
 Control Unit #'s MB- 01 - 02  
 Control Unit #'s MB- 03 - 07

## Sample Hor

E.E.I.  
 Remanufactured R.A.C.  
 E.E.I. Special Design

SB- 01, 02 & 05 - 07  
 SB- 03 & 04  
 SB- 08 - 11

## Impingers - per sample train (each set changed for each test run)

E.E.I.  
 E.E.I.

3 Modified Smith Greenburg type  
 1 Smith Greenburg type

## Probes

## Length

## Lining types

<input type="checkbox"/> E.E.I.	3 foot	SS, PYREX, QUARTZ, TEFILON
<input type="checkbox"/> E.E.I.	5 foot	SS, PYREX, QUARTZ, TEFILON
<input type="checkbox"/> E.E.I.	3 foot	SS, PYREX, TEFILON
<input checked="" type="checkbox"/> E.E.I.	6 foot	SS, PYREX, TEFILON
<input type="checkbox"/> E.E.I.	10 foot	SS, PYREX, TEFILON
<input type="checkbox"/> E.E.I.	12 foot	SS, PYREX, TEFILON
<input type="checkbox"/> E.E.I.	15 foot	SS, PYREX, TEFILON
<input type="checkbox"/> E.E.I.	24 foot	SS, TEFILON

## Temperature Sensors

## Equipment Designation

Omega Engineering  
 Thermo Electric  
 Fluke 51  
 Fisher Scientific  
 Fisher Scientific

PY- 01 & 02  
 PY- 03 - 08  
 PY- 01 - 02 - 03 - 04 - 05  
 Mercury Thermometer  
 Bimetallic Thermometer

## Pressure Gauges

## Type

<input checked="" type="checkbox"/> Dwyer Incline Manometer	Gil, 0 - 10 inch water
<input type="checkbox"/> Dwyer Magnehelic	Magnetic/Mechanical 0 - 1 inch water
<input type="checkbox"/> Dwyer Magnehelic	Magnetic/Mechanical 0 - 10 inch water
<input type="checkbox"/> Dwyer "U" Tube Manometer	Mercury, 36 inches
<input type="checkbox"/> Dwyer "T" Tube Manometer	Water, 72 inches
<input type="checkbox"/> Dwyer Microtector (Micro - Manometer)	Water, 0 - 1 inches of water

## Chemicals and Reagents

Water  
 Acetone  
 Silica Gel  
 Stopcock Grease

Deionized/ Distilled  
 Reagent Grade (<0.001% residual)  
 5 - 16 Mesh  
 Acetone- Insoluble & Heat Resistant

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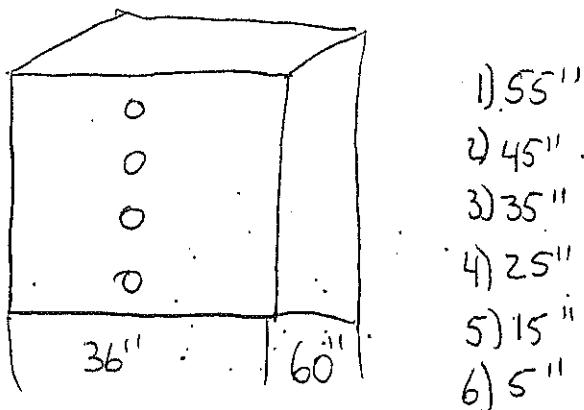
P.O. Box 152 Richfield, Ohio 44286  
 Phone (216) 526-0990

## FIELD DATA SHEETS



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

PLANT HooverDATE 2/18/84SAMPLING LOCATION Boiler outletSAMPLE METHOD 1-GOPERATING TEC.MATERIAL TEMPERATURE 90°FBABCOKE REC. PRESSURE 28.56STATIC PRESSURE -4.6PROBE LENGTH 6'NOZZLE I.D. 0.3125ASSUMED MOISTURE 6%METER BOX NUMBER N.B.METER AS 2 1.81C FACTOR 1.1EFFECT CORRECTION FACTOR .89METER BOX SETTING 325°FTRAVERSE POINT DIAGRAMLOCATION SKETCHTEST TEAM MEMBERS I.C. J.B.



TUMI However

DATE 2/18/26 round 2 CASE# 38 location Boiler Date last page 1 of 1

POINT NUMBER	SAMPLE TIME	GAS WATER HEAD IN	VELOCITY IN	AP HEAD IN	AP HEAD LAP	VENTILATE PRESSURE	SLACK TEMP	GAS BURNER TEMP	PUMP VACUUM	FILTER BOTTOM	IMPINGER HEAD
1	041000	337.40	12	346.070		539	130	106	3.0	510	58
2	3	339.00	18	424	1.08	545	138	106	4.0	310	58
3	6	340.94	24	490	1.45	550	144	107	5.0	315	58
4	9	343.08	25	500	1.50	552	146	108	5.0	320	60
5	12	345.28	25	502	1.50	548	146	108	5.0	320	60
6	15	347.49	26	510	1.53	542	146	109	5.0	330	60
7	18	349.70	22	469	1.40	535	131	109	4.5	340	60
8	21	351.79	22	469	1.40	542	144	110	4.5	330	60
9	24	353.92	24	490	1.45	550	145	110	5.0	330	60
10	27	356.09	25	500	1.50	557	145	110	5.0	330	60
11	30	358.30	27	520	1.60	548	146	111	6.5	325	60
12	33	360.52	25	500	1.50	546	146	111	5.0	330	60
13	36	362.80	29	538	1.75	530	127	111	5.5	330	60
14	39	365.15	27	520	1.60	540	146	111	5.5	330	60
15	42	367.38	25	500	1.5	550	146	111	5.0	330	60
16	45	369.58	22	469	1.40	550	146	111	4.5	330	60
17	48	371.68	22	469	1.40	548	146	112	4.0	335	62
18	51	373.80	20	447	1.20	545	146	111	5.5	340	62
19	54	375.76	30	548	1.80	532	134	111	5.0	330	62
20	57	378.14	30	548	1.80	543	147	112	5.0	330	62
21	60	380.46	28	592	1.65	551	148	112	5.0	335	62
22	63	382.73	24	490	1.45	550	147	112	5.0	331	62
23	66	384.92	19	436	1.15	548	146	112	5.0	329	62
24	69	386.81	16	400	.94	544	144	112	5.0	328	62
	27	388.56	18								

SAMPLE TIME TESTS

PRE-TEST 6 CIR a 15 " " POST-TEST 00411 a 8 " "

PILOT TIME TESTS  
PRE-TEST #2 0@ S. 9 POST-TEST #2 0@ G. 6  
#4 0@ E. 3

S105 1.13 540.916

S105 1.13 540.916

39

61.16

116.5

Inch 1/2

PLATE Hoover

DATE 2/18/94 RUN 3 CASE#100 LOCATION D-6 outlet page 1 of 1

POINT NUMBER	SAMPLE TIME	GAS METER READING	VELOCITY AP HEAD / Ap	ORIFICE PRESSURE	STACK TEMP	GAS METER TEMP IN EXIT	PILOT VACUUM	FILTER HOLDER	IMPINGER TEMP
1	9/12/95	388.80	.20	12.447	1.20	533	130	110	510
2	3	390.76	.24	490	1.45	542	145	110	7.0
3	6	392.70	.24	490	1.45	552	148	111	7.0
4	9	395.04	.26	510	1.53	553	149	111	7.5
5	12	397.27	.25	500	1.50	550	149	112	7.5
6	15	399.42	.25	500	1.50	548	149	113	7.5
1	18	401.63	.24	490	1.45	532	134	113	7.0
2	21	403.72	.24	490	1.45	545	147	113	7.0
3	24	405.85	.24	490	1.45	554	149	113	7.0
4	27	407.99	.25	500	1.50	554	149	114	7.5
5	30	410.20	.27	520	1.60	553	150	114	8.5
6	33	412.43	.24	490	1.45	550	150	115	7.5
1	36	414.60	.20	548	1.80	542	147	114	9.5
2	39	417.11	.27	520	1.60	544	150	115	9.0
3	42	419.32	.23	480	1.38	503	152	115	8.5
4	45	421.38	.20	447	1.20	552	150	115	8.0
5	48	423.42	.23	480	1.38	551	150	113	7.0
6	51	425.47	.18	424	1.08	544	149	116	7.5
1	54	427.38	.30	548	1.80	538	138	115	9.0
2	57	429.61	.28	592	1.65	539	149	115	9.0
3	60	431.93	.24	490	1.45	553	150	115	9.5
4	63	434.16	.19	436	1.15	551	150	116	9.5
5	66	436.20	.18	424	1.08	549	148	116	8.0
6	69	438.07	.16	400	.94	549	146	116	8.0
72	8/02	439.88							

## SAMPLE TUBE LEAK CHECKS

PRE-TEST	008	CIN B	15	"Hg	POST-TEST	002	CIN B	10	"Hg
----------	-----	-------	----	-----	-----------	-----	-------	----	-----

51.0%      48.0%      1.4%      547.08

PRE-TEST	H2	0	CIN C	2	"Hg
----------	----	---	-------	---	-----

130.30

POST-TEST	H2	0	CIN D	5.8	"Hg
-----------	----	---	-------	-----	-----

4

methyl 5

## CALIBRATION SECTION



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

## METER BOX CALIBRATION

Meter Box Number: Anderson # 1Calibration Date: January 17, 1994

$$Y = \frac{V_t P_b (T_m + 460)}{V_m \left[ P_b + \frac{\Delta H}{13.6} \right] (T + 460)}$$

$$\Delta H_{\theta} = \frac{0.0317 \Delta H}{P_b (T_m + 460)} \left[ \frac{(T_t + 460) t}{V_t} \right]$$

Delta H ( $\Delta H$ )	in. H2O	0.5	1.0	3.0	5.0	7.0
Pres. Barometer ( $P_b$ )	in. Hg	29.32	29.32	29.32	29.32	29.32
Vol. Meter Box ( $V_m$ )	cu. ft.	4.039	5.723	9.923	12.820	15.130
Vol. Test Meter ( $V_t$ )	cu. ft.	3.994	5.629	9.700	12.500	14.723
Temp. Meter Box ( $T_m$ )	$^{\circ}$ F	89.0	92.5	98.6	103.1	106.8
	$^{\circ}$ R	549.0	552.5	558.6	563.1	566.8
Temp. Test Meter ( $T_t$ )	$^{\circ}$ F	82.0	82.0	82.0	82.0	82.0
	$^{\circ}$ R	542.0	542.0	542.0	542.0	542.0
Time (t)	minutes	10.0	10.0	10.0	10.0	10.0
METER FACTOR (Y)		1.000	1.000	1.000	1.000	1.000
- Average				1.00		
METER COEFFICIENT ( $\Delta H_{\theta}$ )		1.813	1.814	1.813	1.805	1.810
- Average				1.81		



**Envisage  
Environmental  
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Phone (216) 526-0990

"S" TYPE PITOT TUBE CALIBRATION

43

"S" Type Pitot Tube (Probe) # 106 - 6 ft Probe

Calibration Date: January 4, 1994

$$\frac{C_p}{C_{std}} = \frac{\frac{\Delta P_{std}}{\Delta P_p}}{\sqrt{\frac{\Delta P_{std}}{\Delta P_p}}} \quad (\text{EPA Equation 2-2})$$

where:

$C_p$  = Coefficient of Type S pitot tube, dimensionless

$C_{std}$  = Coefficient of Standard Pitot Tube (0.99), dimensionless

$\Delta P_{std}$  = Velocity head measured by standard pitot tube, inches H<sub>2</sub>O

$\Delta P_p$  = Velocity head measured by Type S pitot tube, inches H<sub>2</sub>O

	$\Delta P_{std}$	$\Delta P_p$	$C_p$
Side A	0.23	0.32	0.839
Side B	0.23	0.32	0.839
Side A	0.63	0.87	0.842
Side B	0.63	0.87	0.842
Side A	1.02	1.41	0.842
Side B	1.02	1.41	0.842
Average -			0.84



**Envisage  
Environmental  
Incorporated**

P.O. Box 152 Richfield, Ohio 44286  
Phone (216) 526-0990

## THERMOCOUPLE CALIBRATION

44

DATE: January 4, 1994

Type: K Sensor #	Reading	Low		Medium		High		Average Deviati
		Ref	Reading	Ref	Reading	Ref	Reading	
1	40	41	80	79	212	212	212	0.67
2	40	40	79	79	212	212	212	0.00
3	41	40	79	80	212	212	212	0.67
4	40	40	79	79	212	212	212	0.00
5	41	41	79	79	212	212	212	0.00
6	43	43	79	79	212	212	212	0.00
7	44	45	79	79	212	212	212	0.33
8	43	44	80	80	212	212	212	0.33
9	44	44	80	80	212	212	212	0.00
10	44	44	80	80	212	212	213	0.33
11	44	45	80	80	212	212	213	0.67
12	45	45	80	80	212	212	212	0.00
13	45	45	79	79	212	212	212	0.00
14	42	41	79	79	212	212	212	0.33
15	42	41	79	79	212	212	212	0.33
16	41	41	80	80	212	212	212	0.00
17	40	40	80	80	212	212	212	0.00
18	40	40	80	80	212	212	213	0.33
19	40	41	82	81	212	212	212	0.67
20	42	41	82	81	212	212	212	0.67
21	42	42	81	81	211	211	212	0.33
22	41	41	81	82	211	211	212	0.67
23	42	42	80	81	212	212	212	0.33
24	44	44	81	81	210	212	212	0.67



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## **EMISSION SAMPLING NOMENCLATURE**



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## SAMPLING NOMENCLATURE

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- A = Cross sectional area of stack or duct, ft.<sup>2</sup>.
- A<sub>n</sub> = Cross sectional area of nozzle entry plane, ft.<sup>2</sup>.
- B<sub>ws</sub> = Water vapor in gas stream, proportion by volume.
- C = Nomograph correction factor, dimensionless.
- C<sub>s</sub> = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.
- D<sub>a</sub> = Nominal diameter of probe nozzle entry plane, in.
- E = Particulate Emission Rate, lb./hr.
- H̄ = Average pressure differential across orifice, in. of H<sub>2</sub>O.
- H̄@ = Orifice meter calibration factor, in. of H<sub>2</sub>O.
- I = Percent of isokinetic sampling, %.
- K<sub>p</sub> = Pitot tube constant, 85.49 ft./sec.
- M<sub>d</sub> = Molecular weight of gas, dry basis, lb./lb.-mole.
- M<sub>n</sub> = Total amount of particulate matter collected, g.
- M<sub>s</sub> = Molecular weight of gas, wet basis, lb./lb.-mole.
- M<sub>w</sub> = Molecular weight of water, 18 lb./lb.-mole.
- P<sub>bar</sub> = Barometric pressure, in. of H<sub>g</sub>.
- P<sub>g</sub> = Pressure differential from gas stream to atmosphere, (static pressure) in. of H<sub>2</sub>O.
- P<sub>s</sub> = Absolute gas stream pressure, (P<sub>bar</sub> + P<sub>g</sub>/13.6) in. of H<sub>g</sub>.
- P<sub>std</sub> = Absolute pressure at standard conditions, 29.92 in. of H<sub>g</sub>.
- P<sub>w</sub> = Density of water, 0.0022 lb./ml.



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SAMPLING NOMENCLATURE - continued

- $\bar{P}_{avg}$  = Average of the square roots of the velocity head readings, in. of  $H_2O$ .
- $Q$  = Volumetric flow rate at gas stream conditions, A.C.F.M.
- $Q_{std}$  = Dry volumetric gas flow rate corrected to standard conditions, D.S.C.F.M.
- $R$  = Ideal gas constant, 21.85 in. of  $H_g$ -ft<sup>3</sup>/ °R-lb.-mole.
- $t$  = Total sampling time, minutes.
- $T_m$  = Average dry gas meter temperature, °R.
- $T_s$  = Average absolute gas stream temperature, °R.
- $T_{std}$  = Standard absolute temperature, 528° rankine.
- $V_{lc}$  = Volume of water collected in impingers and silica gel, ml.
- $V_m$  = Volume of gas sample measured at meter box (meter conditions), ft.<sup>3</sup>.
- $V_{m(std)}$  = Volume of gas sample measured at meter box (corrected to standard conditions), ft.<sup>3</sup>.
- $V_s$  = Average gas stream velocity, ft./sec.
- $V_{w(std)}$  = Volume of water vapor in gas sample (standard conditions), ft.<sup>3</sup>.
- 13.6 = Specific gravity of mercury ( $H_g$ ).
- %CO<sub>2</sub> = Percent by volume of CO<sub>2</sub> in gas stream (dry basis).
- %O<sub>2</sub> = Percent by volume of O<sub>2</sub> in gas stream (dry basis).
- %CO = Percent by volume of CO in gas stream (dry basis).
- %N<sub>2</sub> = Percent by volume of N<sub>2</sub> in gas stream (dry basis).



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- A = Cross sectional area of stack or duct, ft<sup>2</sup>.
- B<sub>ws</sub> = Water vapor in gas stream, proportion by volume.
- C<sub>p</sub> = Pitot tube coefficient, dimensionless.
- C<sub>SO<sub>2</sub></sub> = Concentration of sulfur dioxide, dry basis corrected to standard conditions, lb/dscf.
- E<sub>SO<sub>2</sub></sub> = Sulfur Dioxide Emission Rate, lb/hr.
- $\Delta H$  = Average pressure differential across orifice, in. H<sub>2</sub>O.
- $\Delta H_0$  = Orifice meter calibration factor, in. H<sub>2</sub>O.
- K<sub>p</sub> = Pitot tube constant, 85.49  $\frac{\text{ft}}{\text{sec}} \left[ \frac{(\text{lb/lb-mole})(\text{in.Hg})}{(R)(\text{in.H}_2\text{O})} \right]$
- K<sub>2</sub> = Constant,  $7.061 \times 10^{-5}$  lb/meq.
- M<sub>d</sub> = Molecular weight of gas, dry basis, lb/lb-mole.
- M<sub>s</sub> = Molecular weight of gas, wet basis, lb/lb-mole.
- M.V. = Molar volume at standard conditions of 68° Fahrenheit and 29.92" Hg, 0.84895 ft /mole.
- M.W. = Molecular weight of sulfur dioxide ( 64.0628 g /453.59 g/lb 0.14123 lb/mole.
- M<sub>w</sub> = Molecular weight of water, 18 lb/lb-mole.
- N = Normality of barium perchlorate titrant, milliequivalents/m
- P<sub>bar</sub> = Barometric Pressure, in. Hg.
- P<sub>g</sub> = Pressure differential from gas stream to atmosphere, (static pressure) in.H<sub>2</sub>O.



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- PPM = Concentration of sulfur dioxide emissions, ppmV.
- $P_s$  = Absolute gas stream pressure, ( $P_{bar} + P_g/13.6$ ) in.Hg.
- $P_{std}$  = Absolute pressure at standard conditions, 29.92 in. Hg.
- $P_w$  = Density of water, 0.0022 lb/ml.
- $\bar{P}_{avg}$  = Average of the square roots of the velocity head readings, ( $\sqrt{\bar{p}}$ ) (in. $H_2O$ ).
- $Q$  = Volumetric flow rate at gas stream conditions, A.C.F.M.
- $Q_{sd}$  = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.
- R = Ideal gas constant, 21.85 in. Hg-ft<sup>3</sup>/°R-lb-mole.
- t = Total sampling time, minutes.
- $T_m$  = Average dry gas meter temperature, °R.
- $T_s$  = Average absolute gas stream temperature, °R.
- $T_{std}$  = Standard absolute temperature, 528° Rankine.
- $V_a$  = Volume of aliquot titrated, ml.
- $V_{lc}$  = Volume of water collected in impingers & silica gel, ml.
- $V_m$  = Volume of gas sample measured at meter box (meter conditions), ft<sup>3</sup>.
- $V_{m(std)}$  = Volume of gas sample measured at meter box (corrected to standard conditions), ft<sup>3</sup>.
- $V_s$  = Average gas stream velocity, ft/sec.
- $V_{sln}$  = Total volume of solution in which the sulfur dioxide sample is contained, ml.



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$V_t$  = Volume of barium perchlorate titrant used for the sample, ml (average of replicate titrations).

$V_{tb}$  = Volume of barium perchlorate titrant used for the blank, ml.

$V_w(\text{std})$  = Volume of water vapor in gas sample (standard conditions) ft<sup>3</sup>.

13.6 = Specific gravity of mercury (Hg).

% CO<sub>2</sub> = Percent by volume of CO<sub>2</sub> in gas stream (dry basis).

% O<sub>2</sub> = Percent by volume of O<sub>2</sub> in gas stream (dry basis).

% CO = Percent by volume of CO in gas stream (dry basis).

% N<sub>2</sub> = Percent by volume of N<sub>2</sub> in gas stream (dry basis).



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## EMISSION SAMPLING CALCULATIONS



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## 1) Volume of dry gas sampled through meter box at standard conditions,

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$$V_{m(\text{std})} = V_m \left[ \frac{T_{\text{std}}}{T_m} \right] \left[ \frac{P_b + \frac{\Delta H}{13.6}}{P_{\text{std}}} \right]$$

(EPA Equation 5-1)

Where:

$V_{m(\text{std})}$  = Volume of gas sample measured at meter box (corrected to standard conditions), ft<sup>3</sup>.

$V_m$  = Volume of gas sample measured at meter box (meter conditions), ft<sup>3</sup>.

$T_{\text{std}}$  = Standard absolute temperature, 528° Rankine.

$T_m$  = Average dry gas meter temperature, °R.

$P_{\text{bar}}$  = Barometric Pressure, in. Hg.

$\Delta H$  = Average pressure differential across orifice, in. H<sub>2</sub>O.

13.6 = Specific gravity of mercury (Hg).

$P_{\text{std}}$  = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

$V_m$  = 52.68 ft<sup>3</sup>

$T_m$  = 581.5 °R

$\Delta H$  = 1.52 in. H<sub>2</sub>O

$P_{\text{bar}}$  = 28.96 in. Hg

$$V_{m(\text{std})} = 52.68 \left[ \frac{528.0}{581.5} \right] \left[ \frac{28.96 + \frac{1.52}{13.6}}{29.92} \right]$$

$$= 52.68 (0.9080) (0.9716)$$

$$= 46.48 \text{ ft}^3$$



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$$V_{w(\text{std})} = V_{lc} \left[ \frac{P_w}{M_w} \right] \left[ \frac{(R)(T_{\text{std}})}{P_{\text{std}}} \right]$$

(EPA Equation 5-2)

Where:

- $V_{w(\text{std})}$  = Volume of water vapor in gas sample (standard conditions)  $\text{ft}^3$ .  
 $V_{lc}$  = Volume of water collected in impingers & silica gel, ml.  
 $P_w$  = Density of water, 0.0022 lb/ml.  
 $M_w$  = Molecular weight of water, 18 lb/lb-mole.  
 $R$  = Ideal gas constant, 21.85 in. Hg- $\text{ft}^3/\text{lb-mole}$ .  
 $T_{\text{std}}$  = Standard absolute temperature,  $528^{\circ}$  Rankine.  
 $P_{\text{std}}$  = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

$$V_{lc} = 69.3 \text{ ml}$$

$$V_{w(\text{std})} = 69.3 \left[ \frac{0.0022}{18.0} \right] \left[ \frac{(21.85)}{29.92} \left( \frac{528.0}{\text{Rankine}} \right) \right]$$

$$= 3.26 \text{ ft}^3$$



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3) Moisture content of gas stream,

54

$$B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$$

(EPA Equation 5-3)

Where:

$B_{ws}$  = Water vapor in gas stream, proportion by volume.

$V_{w(std)}$  = Volume of water vapor in gas sample (standard conditions)  $\text{ft}^3$ .

$V_{m(std)}$  = Volume of gas sample measured at meter box (corrected to standard conditions),  $\text{ft}^3$ .

Example: Run 1

$$V_{w(std)} = 3.26 \text{ ft}^3$$

$$V_{m(std)} = 46.48 \text{ ft}^3$$

$$B_{ws} = \frac{3.26}{46.48 + 3.26}$$

$$= 0.0656$$



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$$M_d = 0.440 (\%CO_2) + 0.320 (\%O_2) + 0.280 (\%N_2 + \%CO)$$

(EPA Equation 3-2)

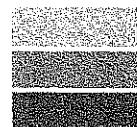
Where:

- $M_d$  = Molecular weight of gas, dry basis, 1b/1b-mole.  
0.440 = Molecular weight of  $CO_2$  divided by 100.  
0.320 = Molecular weight of  $O_2$  divided by 100.  
0.280 = Molecular weight of  $N_2$  or CO (same for both compounds) divided by 100.  
 $\% CO_2$  = Percent by volume of  $CO_2$  in gas stream (dry basis).  
 $\% O_2$  = Percent by volume of  $O_2$  in gas stream (dry basis).  
 $\% CO$  = Percent by volume of CO in gas stream (dry basis).  
 $\% N_2$  = Percent by volume of  $N_2$  in gas stream (dry basis).

Example: Run 1

$$\begin{aligned}\% CO_2 &= 9.4 \\ \% O_2 &= 10.5 \\ \% CO &= 0.0 \\ \% N_2 &= 80.1\end{aligned}$$

$$\begin{aligned}M_d &= 0.440 ( 9.4 ) + 0.320 ( 10.5 ) + 0.280 ( 80.1 ) \\ &= 4.149 + 3.360 + 22.420 \\ &= 29.93 \text{ lb/lb-mole}\end{aligned}$$



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$$M_s = M_d (1 - B_{ws}) + M_w (B_{ws})$$

(EPA Equation 2-5)

Where:

$M_s$  = Molecular weight of gas, wet basis, lb/lb-mole.

$M_d$  = Molecular weight of gas, dry basis, lb/lb-mole.

$B_{ws}$  = Water vapor in gas stream, proportion by volume.

$M_w$  = Molecular weight of water, 18 lb/lb-mole.

Example: Run 1

$$M_d = 29.93 \text{ lb/lb-mole}$$

$$B_{ws} = 0.0656$$

$$M_s = 29.93 (1 - 0.0656) + 18 (0.0656)$$

$$= 27.966 + 1.180$$

$$= 29.15 \text{ lb/lb-mole}$$



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## 6) Average Gas Stream Velocity,

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$$V_s = K_p C_p \sqrt{\frac{T_s}{P_s M_s}}$$

(EPA Equation 2-9)

Where:

 $V_s$  = Average gas stream velocity, ft/sec. $K_p$  = Pitot tube constant, 85.49  $\frac{ft}{sec} \left[ \frac{(lb/lb\text{-mole})(in.Hg)}{(R)(in.H_2O)} \right]^{1/2}$  $C_p$  = Pitot tube coefficient, dimensionless. $\sqrt{\hat{P}_{avg}}$  = Average of the square roots of the velocity head readings, ( $\sqrt{\hat{P}}$ ) (in. $H_2O$ ). $T_s$  = Average absolute gas stream temperature,  $^oR$ . $P_s$  = Absolute gas stream pressure, ( $P_{bar} + P_g/13.6$ ) in.Hg. $P_{bar}$  = Barometric Pressure, in. Hg. $P_g$  = Pressure differential from gas stream to atmosphere, (static pressure) in. $H_2O$ . $M_s$  = Molecular weight of gas, wet basis, lb/lb-mole.

Example: Run 1

 $C_p$  = 0.84 $\sqrt{\hat{P}_{avg}}$  = 0.502 in. $H_2O^{1/2}$  $T_s$  = 1007.7  $^oR$  $P_s$  =  $P_{bar} + P_g/13.6 = 28.96 + -4.60/13.6 = 28.62$  in.Hg $M_s$  = 29.15 lb/lb-mole

$$V_s = (85.49)(0.84)(0.502) \sqrt{\frac{1007.7}{(28.62)(29.15)}}$$

$$= 39.62 \text{ ft/sec}$$



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7) Volumetric Flow Rate at Gas Stream Conditions,

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$$Q = A \times V_s \times 60$$

Where:

$Q$  = Volumetric flow rate at gas stream conditions, A.C.F.M.

$A$  = Cross sectional area of stack or duct,  $\text{ft}^2$ .

$V_s$  = Average gas stream velocity,  $\text{ft/sec}$ .

60 = Conversion factor from seconds to minutes.

Example: Run 1

$$A = 15.00 \text{ ft}^2$$

$$V_s = 39.62 \text{ ft/sec}$$

$$Q = (15.00) (39.62) 60$$

$$= 35,658 \text{ ACFM}$$



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8) Volumetric Flow Rate at Standard Conditions,

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$$Q_{sd} = 60 \left( 1 - B_{ws} \right) V_s A \left[ \frac{T_{std}}{T_s} \right] \left[ \frac{P_s}{P_{std}} \right]$$

Where:

(EPA Equation 2-10)

$Q_{sd}$  = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

60 = Conversion factor from seconds to minutes.

$B_{ws}$  = Water vapor in gas stream, proportion by volume.

$V_s$  = Average gas stream velocity, ft/sec.

$A$  = Cross sectional area of stack or duct,  $\text{ft}^2$ .

$T_{std}$  = Standard absolute temperature,  $528^{\circ}$  Rankine.

$T_s$  = Average absolute gas stream temperature,  $^{\circ}\text{R}$ .

$P_s$  = Absolute gas stream pressure,  $(P_{bar} + P_g/13.6)$  in.Hg.

$P_{bar}$  = Barometric Pressure, in. Hg.

$P_g$  = Pressure differential from gas stream to atmosphere, (static pressure)  $\text{in.H}_2\text{O}$ .

$P_{std}$  = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

$$B_{ws} = 0.0656$$

$$V_s = 39.62 \text{ ft/sec}$$

$$A = 15.00 \text{ ft}^2$$

$$T_s = 1007.7 \text{ } ^{\circ}\text{R}$$

$$P_s = P_{bar} + P_g/13.6 = 28.96 + -4.60/13.6 = 28.62 \text{ in.Hg}$$

$$Q_{sd} = 60 \left( 1 - 0.0656 \right) ( 39.62 ) ( 15.00 ) \left( \frac{528.0}{1007.7} \frac{28.62}{29.92} \right)$$

$$= 16,701 \text{ SCFM}$$



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## 9) Gas Stream Particulate Concentration,

60

$$C_s = 15.43 \text{ gr./g} \quad \left[ \frac{M_n}{V_{m(\text{std})}} \right]$$

(EPA Equation 5-6)

Where:

$C_s$  = Concentration of urea in gas stream, dry basis-corrected to standard conditions, gr/dscf.

$M_n$  = Total amount of particulate collected in imingers, g

$V_{m(\text{std})}$  = Volume of gas sample measured at meter box (corrected to standard conditions), ft<sup>3</sup>.

Example: Run 1

$$M_n = 0.1526 \text{ g}$$

$$V_{m(\text{std})} = 46.48 \text{ ft}^3$$

$$C_s = 15.43 \quad \left[ \frac{0.15}{46.48} \right]$$

$$= 0.0507 \text{ gr/dscf}$$



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$$E = Q_{sd} C_s \left[ \frac{1 \text{ pound}}{7000 \text{ grains}} \right] \left[ \frac{60 \text{ minutes}}{1 \text{ hour}} \right]$$

Where:

$E$  = Particulate Emission Rate, lb/hr.

$Q_{sd}$  = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

$C_s$  = Concentration of particulate in gas stream, dry basis-corrected to standard conditions, gr/dscf.

Example: Run 1

$$Q_{sd} = 16,701 \text{ ft}^3$$

$$C_s = 0.0507 \text{ gr/dscf}$$

$$E = (16,701) (0.0507) \left[ \frac{60}{7000} \right]$$

$$= 7.25 \text{ lb/hr}$$



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## 11) Percent of Isokinetic Sampling,

62

$$I = \frac{100}{60} \frac{T_s}{A_n} \left[ K_3 V_{1c} + \left( \frac{V_m}{T_m} \right) \left( P_{bar} + \frac{\Delta H}{13.6} \right) \right] t \quad (\text{EPA Equation 5-7})$$

Where:

- $I$  = Percent of Isokinetic sampling, %.  
 $T_s$  = Average absolute gas stream temperature,  $^{\circ}\text{R}$ .  
 $K_3$  = Constant, 0.002669 in.Hg-ft $^3$ /ml- $^{\circ}\text{R}$ .  
 $V_{1c}$  = Volume of water collected in impingers & silica gel, ml.  
 $V_m$  = Gas sample volume measured at meter box (meter conditions), ft $^3$ .  
 $T_m$  = Average dry gas meter temperature,  $^{\circ}\text{R}$ .  
 $P_{bar}$  = Barometric Pressure, in. Hg.  
 $\Delta H$  = Average pressure differential across orifice, in. H<sub>2</sub>O.  
 $t$  = Total sampling time, minutes.  
 $V_s$  = Average gas stream velocity, ft/sec.  
 $P_s$  = Absolute gas stream pressure, in.Hg.  
 $D_n$  = Nominal diameter of probe nozzle tip, inches.  
 $A_n$  = Cross sectional area of nozzle, ft $^2$ .

## Example: Run 1

$T_s$	=	1007.7 $^{\circ}\text{R}$	$\Delta H$	=	1.52 in.H <sub>2</sub> O
$V_{1c}$	=	69.3 ml	$t$	=	72.0 min.
$V_m$	=	52.68 ft $^3$	$V_s$	=	39.62 ft/sec
$T_m$	=	581.5 $^{\circ}\text{R}$	$P_s$	=	28.62 in.Hg
$A_n$	=	0.0005326 ft $^2$	$P_{bar}$	=	28.96 in.Hg

$$I = \frac{1007.7 (100)}{60 (0.0005326)} \left[ 0.002669 (69.3) + \left( \frac{52.68}{581.5} \right) \left( 28.96 + \frac{1.52}{13.6} \right) \right] (72.0)$$

$$= 108.9 \%$$



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Gas Stream Sulfur dioxide Concentration (lb/dscf),

63

$$C_{SO_2} = K_2 \frac{(V_t - V_{tb}) N}{V_{m(std)}} \left[ \frac{V_{sln}}{V_a} \right]$$

(EPA Equation 6-2)

Where:

- $C_{SO_2}$  = Concentration of sulfur dioxide, dry basis corrected to standard conditions, lb/dscf.
- $K_2$  = Constant,  $7.061 \times 10^{-5}$  lb/meq.
- $V_t$  = Volume of barium perchlorate titrant used for the sample, ml (average of replicate titrations).
- $V_{tb}$  = Volume of barium perchlorate titrant used for the blank, ml.
- $N$  = Normality of barium perchlorate titrant, milliequivalents/ml.
- $V_{sln}$  = Total volume of solution in which the sulfur dioxide sample is contained, ml.
- $V_a$  = Volume of aliquot titrated, ml.
- $V_{m(std)}$  = Volume of gas sample measured at meter box (corrected to standard conditions), ft<sup>3</sup>.

Example: Run 1

- $V_t$  = 5.6 ml
- $V_{tb}$  = 0.0 ml
- $N$  = 0.0106 meq/ml
- $V_{sln}$  = 255.0 ml
- $V_a$  = 0.1 ml
- $V_{m(std)}$  = 46.48 ft<sup>3</sup>

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{(5.6 - 0.0)}{46.48} \frac{0.0106}{\left[ \frac{255.0}{0.1} \right]}$$

$$= 7.061 \times 10^{-5} \frac{152.26}{46.48}$$

$$= 2.3132 \times 10^{-4} \text{ lb/dscf}$$



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Gas Stream Sulfur dioxide Concentration (ppm),

$$\text{PPM} = C_{\text{SO}_2} \left[ \frac{\text{M.V.}}{\text{M.W.}} \right] \times 10^6$$

Where:

PPM = Concentration of sulfur dioxide emissions, ppmV.

$C_{\text{SO}_2}$  = Concentration of sulfur dioxide, dry basis corrected to standard conditions, 1b/dscf.

M.V. = Molar volume at standard conditions of  $68^0$  Fahrenheit and 29.92" Hg,  $0.849531 \text{ ft}^3/\text{mole}$ .

M.W. = Molecular weight of sulfur dioxide ( $64.0628 \text{ g}/453.59 \text{ g/lb}$ ),  $0.141235 \text{ lb/mole}$ .

Example: Run 1

$$C_{\text{SO}_2} = 2.313E-04 \text{ lb/dscf}$$

$$\text{PPM} = 2.313E-04 \left[ \frac{0.849531}{0.141235} \right] \times 10^6$$

$$= 1391.4 \text{ ppmV}$$



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Sulfur dioxide Emission Rate,

$$E_{SO_2} = C_{SO_2} Q_{sd} \left[ \frac{60 \text{ minutes}}{1 \text{ hour}} \right]$$

Where:

$E_{SO_2}$  = Sulfur Dioxide Emission Rate, lb/hr.

$Q_{sd}$  = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

$C_{SO_2}$  = Concentration of sulfur dioxide, dry basis corrected to standard conditions, lb/dscf.

Example: Run 1

$Q_{sd}$  = 16,703 SCFM

$C_{SO_2}$  = 2.313E-04 lb/dscf

$$E_{SO_2} = (2.313E-04) (16,703) (60)$$

$$= 231.82 \text{ lb/hr}$$



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